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# Invertebrate communities from different wetland types of Tierra del Fuego

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**Abstract.** 1. Loss or deterioration of wetlands, which represent highly valuable environments, is a worldwide phenomenon. Sustainable management of wetlands, however, requires detailed understanding of the factors controlling their communities. The present study report the taxonomic composition and richness of invertebrate assemblages in different wetland types in Tierra del Fuego.

2. Aquatic invertebrates from 79 freshwater wetlands in Tierra del Fuego were inventoried in January 2001 and 2002 (austral summer). All wetlands were classified into six categories: roadside pools, floodplain pools, flooded quarries, peatland ponds, beaver ponds and large ponds. The wetland type effect on the taxonomic richness was analysed by one-way ANOVA. To identify wetland types with similar invertebrate communities, cluster analysis has been performed using occurrence frequency of each taxa in each wetland type and the Jaccard similarity index.

3. A total of 35 taxa were identified, including 21 microcrustaceans, 12 insects, 1 gastropod and 1 cnidarian. Copepods and cladocerans were among the most frequent taxa (occurrence frequency $>40\%$) in most wetland types. No significant differences in taxonomic richness were found among wetlands types ($P = 0.076$). The cladogram based on invertebrate taxonomic composition resulting from similarity in taxonomic composition among wetland types showed three distinct clusters; one included flooded quarries, peatland ponds, beaver ponds and floodplain pools, the second one the large ponds and the third one roadside pools.

4. Our results suggest that the wetland types studied have different conservation values, like the clusters obtained in the cladogram show. Artificial wetlands, such as the roadside pools, could play an important role in maintaining connectivity between isolated fragments of pristine, natural wetlands.

**Key words.** Insects, macroinvertebrates, microcrustaceans, richness, South America.

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## Introduction

Wetlands provide key resources for different groups of organisms, including humans. Most of their functions can be classified into three major categories, namely hydrologic, biogeochemical and biological (Lewis, 1995). For example, some of their functions are improvement of water quality by retention and export of nutrients (Howard-Williams, 1985), supply of water for aquifer charge and recharge, and flood mitigation (De Laney, 1995). Wetlands also provide food for a wide range of aquatic organisms (Chabreck, 1988; van der Valk, 1989). Despite their key role, many wetlands have been lost or degraded because of the anthropogenic activities, mainly over the past century (Williams, 1997; Brown, 1998; Wood *et al*., 2003). Wetland loss or degradation may not only alter the community of aquatic invertebrates, but also affect other organisms linked to them. The multiple roles of wetlands and their importance have been increasingly understood and documented in recent years. Many efforts have been made to minimise further loss of wetlands, and to restore their functions, where these have been impaired (Ramsar, 1996). A more complete knowledge of the characteristics of wetlands communities and their relationship with environmental variables is of fundamental importance for a better understanding of these environments. Without this information, wetland restoration is likely to be hindered or even impossible.

The condition of most of the small wetlands in Argentina is unknown as a result of the lack of conservation policies at a national scale. Although, some activities are currently being taken to develop a system for the classification and inventory of wetlands (Malvárez & Bó, 2004; Benzaquén *et al*., 2009), this work is still incomplete. An example of this is provided by the wetlands of the Grand Island of Tierra del Fuego, located at the southernmost tip of South America, where information on freshwater invertebrates is fragmentary and only involves taxonomic keys to insects (e.g. Bachmann, 1981; Bachmann & Trémouilles, 1981; Lizarralde de Grosso, 1998; Paggi A, 1998), microcrustacean systematics (Ringuelet, 1958; Olivier, 1962; Paggi JC, 1998), and geographic distribution and genetics of microcrustaceans (Mariazzi *et al*., 1987; Adamowicz *et al*., 2002, 2004). Tierra del Fuego has experienced a relatively low level of anthropogenic impact (Collantes & Faggi, 1999). Therefore, the study of the freshwater invertebrate communities inhabiting wetlands may provide baseline information to serve as reference for biomonitoring or conservation activities.

The objective of this study is to report the taxonomic composition and richness of invertebrate assemblages in different wetland types in the Argentine sector of the Grand Island of Tierra del Fuego.

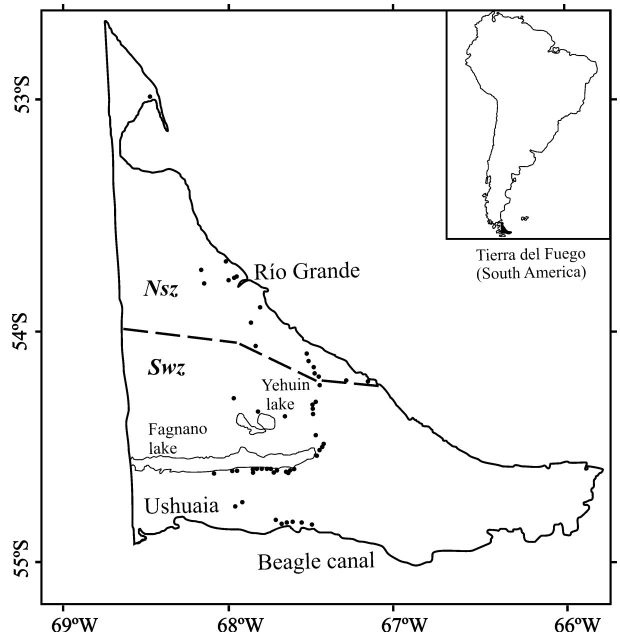


**Fig. 1.** Location of Grand Island of Tierra del Fuego in the southern part of Argentina, and all wetlands surveyed in the Argentine portion of this island in January 2001 and 2002. The dashed line indicates the approximate limit between the northern steppe (*Nsz*) and the southern woodland (*Swz*) zones.

## Materials and methods

### *Study area*

Grand Island of Tierra del Fuego is characterised by a cold temperate climate, small thermal amplitude, absence of frost-free periods, and precipitation regularly distributed throughout the year (Chiozza & Figuera, 1982). The thermal regime is colder than similar latitudes in Europe due to the oceanic influence of the cold Malvinas Current (Collantes & Faggi, 1999).

Two main phytogeographical regions are recognised in the Argentine portion of the island, the northern steppe zone and the southern woodland zone (Collantes & Faggi, 1999). The northern steppe zone extends from the northern part of the island (52°59′15″S) to 53°55′9″S at the western limit and to 54°11′46″S at the eastern limit (Fig. 1). Annual precipitation ranges between 300 and 400 mm and annual mean temperature ranges between 5 and 6 °C (Paruelo *et al*., 1998). The landscape is an open steppe with large plains and isolated hills and plateaus. The predominant vegetation is represented by tussocks of *Festuca gracillima* in uplands and marshy prairies of cyperaceans in wetlands (Collantes & Faggi, 1999). The southern woodland zone extends from 53°55′9″S at the western limit to 54°11′46″S at the eastern limit and to Beagle Channel at the southern limit (55°00′19″S). It is sheltered from winds by the Andes Mountains and is characterised by annual precipitations of ~500 mm and mean temperatures of ~4 °C (Paruelo *et al*., 1998). It is mostly forested with *Nothofagus pumilio* ('lenga'), *Nothofagus antarctica* ('ñire'), *Nothofagus obliqua* ('pellín oak') and *Nothofagus alpina* ('raulí') (Cabrera, 1971).

### *Sample collection and data analysis*

Different freshwater bodies in the Argentine sector of Tierra del Fuego were sampled during the austral summer, from 22 to 26 January 2001 and from 8 to 14 January 2002. All sampled wetlands were located within of 500 m from the main roads.

Wetlands were classified *a posteriori* into the following wetland types according to their origin and substrate type: (i) roadside pools (i.e. artificial water bodies created by road construction, with clayey and muddy substrate); (ii) floodplain pools (i.e. water bodies originated from stream or river overflow, mainly after the spring thaw, with muddy and/or clayey substrate); (iii) flooded quarries (i.e. artificial water bodies originated from excavation for road construction, with stony substrate); (iv) peatland ponds (i.e. natural water bodies located in *Sphagnum* peatlands, with moss or muddy substrate), (v) beaver ponds (i.e. water bodies resulting from the activity of beavers, with muddy substrate) and (vi) large ponds (i.e. natural water bodies larger than roadside pools, with muddy-sandy substrate).

Each water body was sampled on a single occasion, so water bodies visited in the first year differed from those sampled in the second year. The following environmental variables were measured: (i) maximum depth (shallower or deeper than 1 m); wetlands were waded from the border to the centre or up to 1 m in depth; (ii) water turbidity (turbid or transparent); turbidity was estimated visually using a white container of 20 cm in diameter and 15 cm in height; water was considered turbid when the white container background could not be seen. (iii) Presence of gramineans, macrophytes and/or macroscopic algae (cyanobacteria and filamentous chlorophyceans). These were recorded as present, if they covered at least 30% of the sampling area.

Invertebrates were collected with a 350 $\mu$m-mesh hand net. The nets were swept through the water column and turned back along the same path to collect dislodged organisms (O'Connor *et al*., 2004). Three people sampled each habitat for 20–30 min. Samples were taken in open water and in the littoral zone in wetlands $<1$ m deep, and only in the littoral zone in wetlands $>1$ m deep.

Specimens collected were preserved in 80% ethanol and identified to the lowest possible taxonomic level using taxonomic keys, original descriptions and reference works. Culicids, coleopterans, heteropterans, cladocerans, copepods, anostracans and amphipods were identified to species or genus level (Darsie, 1985; Bachmann, 1981; Bachmann & Angrisano, 1998; Reinert, 2000; Ringuelet, 1958; Reid, 1985; Cohen, 1995; Paggi, 1995; Paggi, 1999; Menu Marque, 2003). Trichopterans, odonates, non-culicid dipterans and ostracods were identified to suborder or family level (Bachmann & Angrisano, 1998). Adult and immature insects were counted separately. Hydrozoans were identified in the field with the aid of a hand-held magnifying glass.

### *Statistical analysis*

The frequency of occurrence of each taxon was defined as the number of times a taxon was present in a wetland type. The wetland type effect on the taxonomic richness was analysed by one-way ANOVA (Zar, 1999). To identify wetland types with similar invertebrate communities, cluster analysis has been performed using occurrence frequency of each taxa in each wetland type and the Jaccard similarity index. The Euclidean distance was used as distance measure and the single-linkage method was used for cluster analysis (Gauch, 1982). The different steps of the algorithm and the distance at which occurs the fusion of the groups were observed. The first step in which the distance increased in a sharp way was chosen as group cut off.

## Results

Both in the southern woodland zone as in the northern steppe zone, the roadside pools were sampled more frequently than in the other wetlands, probably because they were adjacent to roads. Peatland ponds and beaver ponds were exclusive to the southern woodland zone (Table 1). Wetlands features are shown in Table 2.

A total of 35 taxa were found, including 21 microcrustaceans, 12 insects, 1 gastropod and 1 cnidarian. Only three taxa occurred between 53% and 56% of all sampled wetlands, i.e. *Boeckella* (*Pseudoboeckella*) spp., cyclopoid copepods and Chironomidae.

**Table 1.** Number of types of wetlands sampled in the northern steppe and southern woodland zones in the Argentine portion of Grand Island of Tierra del Fuego. January 2001 and 2002.

| | Roadside pools | Flooded quarries | Floodplain pools | Peatland ponds | Beaver ponds | Large ponds |
|---|---|---|---|---|---|---|
| Northern steppe zone | 11 | 2 | 3 | – | – | 1 |
| Southern woodland zone | 37 | 3 | 6 | 7 | 5 | 4 |
| Total | 48 | 5 | 9 | 7 | 5 | 5 |

**Table 2.** Environmental conditions in different wetland types. Numbers are percent of wetlands with those characteristics.

| Environmental variable | Roadside pools | Floodplain pools | Flooded quarries | Peatland ponds | Beaver ponds | Large ponds |
|---|---|---|---|---|---|---|
| Vegetation | | | | | | |
| Macrophytes | 15 | 22 | 20 | 43 | 20 | 60 |
| Gramineae | 31 | 11 | 0 | 14 | 0 | 0 |
| Filamentous chlorophytes | 25 | 22 | 20 | 14 | 40 | 60 |
| Crustaceous cyanobacteria | 8 | 11 | 0 | 0 | 0 | 0 |
| Turbid | 54 | 25 | 75 | 0 | 20 | 20 |
| Depth $<1$ m | 94 | 89 | 100 | 57 | 0 | 80 |

**Table 3.** Frequency of occurrence of taxa in each wetland type. L, larva; N, nymph; P, pupa; A, adult. (a) In the present analysis, the species of *Boeckella* were grouped into two 'subgenera' or biotypes, following the old taxonomical scheme for the genus: *Boeckella* (*Pseudoboeckella*) spp. (*B. poppei*, *B. brevicaudata* and *B. brasiliensis*) and *Boeckella* (*Boeckella*) spp. (*B. michaelseni, B. gracilipes* and *B. meteoris*). (b) Within the genus *Lancetes*, the only species identified were *L. angusticollis*, *L. nigriceps nigriceps* and *L. varius rotundicollis*.

| Taxa | Roadside pools (48) | Flooded quarries (5) | Floodplain pools (9) | Peatland ponds (7) | Beaver ponds (5) | Large ponds (5) | Total (79) |
|---|---|---|---|---|---|---|---|
| Crustacea | | | | | | | |
| Cladocera | | | | | | | |
| Daphniidae | | | | | | | |
| *Ceriodaphnia* cf. *dubia* Richard, 1895 | 13 | 2 | 4 | 3 | 4 | 2 | 28 |
| *Daphnia* (*D.*) *commutata* Ekman, 1900 | 5 | 0 | 2 | 0 | 1 | 1 | 9 |
| *Daphnia* (*D.*) 'group obtusa' sp. nov. | 16 | 1 | 4 | 1 | 4 | 1 | 27 |
| *Daphnia* (*D.*) *pulicaria* Forbes, 1893 | 8 | 1 | 1 | 2 | 0 | 2 | 14 |
| *Daphnia* (*C.*) *dadayana* Paggi, 1999 | 4 | 0 | 0 | 0 | 0 | 0 | 4 |
| *Daphnia* (*C.*) sp. nov. | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Scapholeberis spinifera* (Nicolet, 1879) | 11 | 1 | 6 | 2 | 1 | 3 | 24 |
| *Simocephalus* cf. *vetulus* (O.F.Müller, 1776) | 12 | 2 | 6 | 3 | 4 | 2 | 29 |
| Bosminidae | | | | | | | |
| *Bosmina chilensis* Daday, 1902 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Macrothricidae | 2 | 0 | 0 | 0 | 0 | 1 | 3 |
| Chydoridae | | | | | | | |
| *Alona* spp. | 11 | 2 | 2 | 1 | 3 | 3 | 22 |
| *Chydorus* spp. | 14 | 1 | 3 | 1 | 4 | 2 | 25 |
| *Pleuroxus* spp. | 8 | 1 | 2 | 1 | 2 | 0 | 14 |
| Copepoda | | | | | | | |
| Calanoida | | | | | | | |
| Centropagidae | | | | | | | |
| *Boeckella* (*Pseudoboeckella*) spp. (a) | 29 | 2 | 3 | 3 | 4 | 3 | 44 |
| *Boeckella* (*Boeckella*) spp. (a) | 7 | 2 | 1 | 1 | 1 | 2 | 14 |
| *Parabroteas sarsi* (Daday, 1902) | 6 | 1 | 1 | 0 | 1 | 1 | 10 |
| Cyclopoida | 23 | 2 | 7 | 4 | 4 | 4 | 44 |
| Harpacticoida | 2 | 2 | 1 | 0 | 2 | 2 | 9 |
| Anostraca | | | | | | | |
| Branchinectidae | | | | | | | |
| *Branchinecta granulosa* Daday, 1902 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| Ostracoda | 9 | 2 | 5 | 1 | 2 | 1 | 20 |
| Amphipoda | | | | | | | |
| Hyalellidae | | | | | | | |
| *Hyalella* sp. | 11 | 0 | 4 | 2 | 2 | 2 | 21 |
| Insecta | | | | | | | |
| Odonata | | | | | | | |
| Anisoptera N | 2 | 0 | 1 | 0 | 0 | 0 | 3 |
| Hemiptera | | | | | | | |
| Corixidae N | 6 | 3 | 1 | 2 | 2 | 2 | 16 |
| *Ectemnostega* (*Ectemnostega*) *quadrata* (Signoret, 1985) | 0 | 0 | 2 | 0 | 1 | 0 | 3 |
| Coleoptera | | | | | | | |
| Haliplidae | | | | | | | |
| *Haliplus* (*Haliplus*) *subseriatus* Zimmermann, 1921 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Haliplus* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Hydrophilidae L | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Dytiscidae | | | | | | | |
| *Lancetes* sp. L-A (b) | 18 | 2 | 6 | 1 | 2 | 2 | 31 |
| *Liodessus* sp. A | 4 | 0 | 0 | 0 | 2 | 0 | 6 |
| Trichoptera | | | | | | | |
| Limnephilidae L | 1 | 0 | 1 | 0 | 0 | 1 | 3 |

**Table 3.** (*Continued*)

| Taxa | Roadside pools (48) | Flooded quarries (5) | Floodplain pools (9) | Peatland ponds (7) | Beaver ponds (5) | Large ponds (5) | Total (79) |
|---|---|---|---|---|---|---|---|
| Diptera | | | | | | | |
| Culicidae | | | | | | | |
| *Ochlerotatus albifasciatus* L Macquart, 1938 | 8 | 0 | 0 | 0 | 0 | 0 | 8 |
| Chironomidae L-P | 20 | 4 | 5 | 5 | 4 | 4 | 42 |
| Ephydridae L | 1 | 0 | 1 | 0 | 0 | 2 | 4 |
| Cnidaria | | | | | | | |
| *Hydra* spp. | 2 | 1 | 3 | 1 | 2 | 0 | 9 |
| Mollusca | | | | | | | |
| Gastropoda | 5 | 0 | 4 | 1 | 1 | 0 | 11 |
| Total taxa by wetland types | 31 | 18 | 26 | 19 | 22 | 22 | |
| Total taxa | | | | | | | 35 |
| Mean richness/wetland (±SD) | 5.5 (±4.36) | 6.4 (±3.58) | 8.6 (±5.92) | 5.1 (±2.97) | 10.6 (±4.98) | 8.6 (±3.36) | |

Six cladocerans [*Simocephalus* cf. *vetulus* (O.F. Müller, 1776), *Ceriodaphnia* cf. *dubia* Richard 1895, *Daphnia* (*Daphnia*) 'obtusa group' sp. nov., *Scapholeberis spinifera* (Nicolet, 1879), *Alona* spp. and *Chydorus* spp.], Ostracoda, *Hyalella* sp., *Branchinecta granulosa* Daday, 1902, and two insects (*Lancetes* spp. and Corixidae) occurred in between 20% and 40% of all sampled wetlands. The other taxa present were in $<20\%$ (Table 3).

Most of the insect ($>90\%$) and microcrustacean ($>95\%$) taxa were found in roadside pools. The other wetland types had 3–7 insect taxa and 14–16 crustacean taxa (Table 3). However, no significant differences were found in taxonomic richness among wetland types [$F(1, 5) = 2.095$; $P = 0.076$].

Thirteen taxa were present in all wetland types, six cladocerans, three copepods, Ostracoda and three insect taxa. Copepods and cladocerans were the most frequent taxa (frequency of occurrence $>40\%$) in all wetland types except for flooded quarries (Table 3).

The cladogram based on similarities in the taxonomic composition among wetland types showed three distinct clusters (Fig. 2). One cluster included the flooded quarries, peatland ponds, beaver ponds and floodplain pools, a second cluster the large ponds and a third cluster the roadside pools. The habitats included in the cluster that grouped four wetland types, shared fifteen taxa, seven cladocerans [*Ceriodaphnia* cf. *dubia*, *Daphnia* (*D.*) 'group obtusa' sp. nov., *S. spinifera*, *Simocephalus* cf. *vetulus*, *Alona* spp., *Chydorus* spp., *Pleuroxus* spp.]; three copepods [*Boeckella* (*Pseudoboeckella*) spp., *Boeckella* (*Boeckella*) spp., *Cyclopoida*]; three insects (Corixidae, *Lancetes*, sp. Chironomidae) and Cnidaria (*Hydra* sp.).

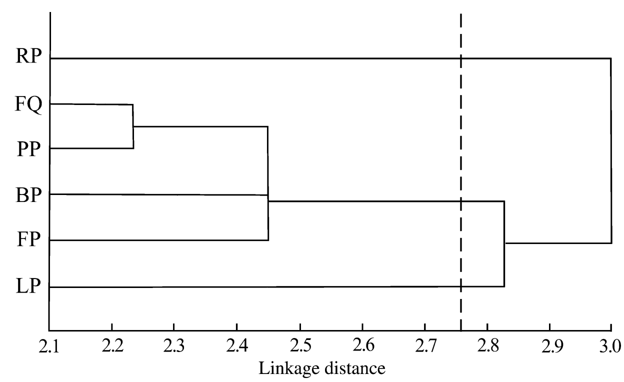


**Fig. 2.** Cluster dendrogram summarising similarities in taxonomic composition among wetland types using taxon presence/absence. Euclidean distance as distance measure and the single-linkage as method of grouping were used. The wetland types are represented by: RP (Roadside pools), FQ (Flooded quarries), PP (Peatland ponds), BP (Beaver ponds), FP (Floodplains pools) and LP (Large ponds).

## Discussion

The predominance of roadside pools in comparison with the other wetland types could be due to a sampling artefact; soil depressions left after road construction accumulate water, and sampling was performed near main roads. Floodplain pools and large ponds were more abundant in the southern woodland zone, which is the most humid part of the island and contains a large number of streams and rivers. Beaver ponds were not found in the northern steppe zone, probably due to the phytogeographical characteristics of this region. Beavers were introduced in the island in 1946 (Lizarralde & Escobar, 2000); since then they have expanded their range dramatically in a short time, becoming a nuisance.

Despite the limited number of environmental variables considered, some general patterns can be detected. The roadside pools showed variable turbidity and the flooded quarries were frequently turbid, while low turbidity was observed in the beaver ponds, large ponds and floodplain pools. Possibly in water bodies of low depth, the wind causes sediment resuspension increasing water turbidity. However, this effect would be reduced if this water body has grass. In deep wetlands, the interception of nutrients by macrophytes could greatly reduce the turbidity (Carpenter & Lodge, 1986; Izaguirre & Vinocur, 1994). The presence of cyanobacteria in roadside pools and floodplain pools suggests periodic flooding and desiccation, as these organisms are adapted to withstand drought (Whitton & Potts, 2000).

The similar taxonomic richness among the wetland types studied could be due to the fact that invertebrates were identified to different taxonomic levels and some groups included many genera. On the other hand, similar specific richness between natural and artificial wetland types suggests that they play a similar role in maintaining invertebrate biodiversity in Tierra del Fuego.

The most frequent taxa encounted were microcrustaceans (i.e. cladocerans, ostracods and copepods) and three insect groups [Corixidae, Coleoptera (*Lancetes* spp.) and Chironomidae]. This could be an artefact of the sampling method since individuals inhabiting non-sampled areas, i.e. deep open-water zones, were excluded from the analysis, or organisms capable of rapid movement may be able to avoid the sweep net. Copepods and cladocerans were present in most of the habitats, possibly due to physiological adaptations such as dormancy mechanisms (Williams, 1998) and resistant stages (Wiggins *et al*., 1980). At sites under certain climatic conditions such as Tierra del Fuego (i.e. freezing conditions) these strategies lead to a more efficient resource exploitation. The dominance of chironomids and corixids could be related to their generalist and pioneer status, (Bachmann, 1981; Paggi, A 1998) and great dispersal capacity (Paterson & Fernando, 1969; Velasco *et al*., 1998). In addition, another explanation for the presence of copepods and cladocerans on most sites is that these taxa are present in all aquatic habitats.

Our results suggest that wetland types studied in Tierra del Fuego have different conservation values, as shown by the different groups of the cladogram obtained from the compositions of invertebrate communities. Moreover, even man-made wetlands are likely to make a substantial contribution to biodiversity. In fact, roadside pools and flooded quarries may play an important role in the dispersal of aquatic invertebrates by connecting different isolated fragments of pristine habitats. Since environmental conditions affect the various taxa that could be present in a given habitat, the factors associated with biodiversity in the different wetland types in Tierra del Fuego is worthy of further studies.

During the last century, many wetlands have been lost as a result of anthropogenic activity, and those that still remain are being subjected to increasing pressures mainly represented by agricultural land drainage pollution and urban development (Williams, 1997; Brown, 1998; Wood *et al*., 2003). The establishment of protected areas is a measure often used to prevent biodiversity loss. In this regard, many natural areas in Tierra del Fuego have recently been designated as protected areas (Loekemeyer *et al*., 2005). Unfortunately, wetland aquatic invertebrates are not considered to be relevant to conservation policies due to lack of data. On this basis, the information provided by this study may contribute to the knowledge of these complex ecosystems.

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